Control of the grain size distribution of the raw material mixture in the production of iron sinter

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Transaction Paper

Synopsis

The aim of this study was to examine the effect of grain size distribution control of the raw material mixture on the permeability of the green sinter bed and the properties of the produced sinter. This was achieved by evaluating the granulation characteristics of the sinter mixture (moisture content, granulation time and mean granule diameter) in terms of its green bed permeability, and evaluating the productivity of the sinter bed, the coke rate, tumble index (TI), abrasion index (AI), reduction disintegration index (RDI) and reducibility (RI) of the produced sinter. The raw sinter mixtures contained combinations of Thabazimbi iron ore, Sishen iron ore, coke, lime and return fines. The grain size distributions were controlled by removing the –0.5 mm size fractions of the return fines and coke, and the –1 mm size fraction of lime. Of the examined mixtures, a mixture of 20 mass% Thabazimbi iron ore, 80 mass% Sishen iron ore and fluxes where the coke, lime and return fines were all sized had the highest granulation effectiveness and permeability. The sintering properties of the mixtures in which the grain size distributions were controlled, were very similar for all the mixtures, but superior to the base case mixture in which the grain size distribution was not controlled.

Keywords: Thabazimbi iron ore; Sishen iron ore; granulation, permeability, grain size distribution; sinter.

Introduction

In the majority of production processes, the particle size distributions of the raw materials influence the properties of the product. This also pertains to iron sinter, which is constituted of a mixture of raw materials (iron ore, coke breeze, limestone, lime, dolomite, return fines) all of which have various size distributions. Although ArcelorMittal Vanderbijlpark has fixed specifications on the physical and chemical properties of the produced sinter for optimal blast furnace performance, the particle size distribution of their sinter mixture has not yet been optimized. The main purpose of this study was therefore to examine the effect of particle size distribution control of the raw material mixture on the quality of the produced sinter.

Background

Only a limited amount of fine iron ore particles can be directly charged to the blast furnace, as they are detrimental to the permeability and gas flow distribution in the blast furnace, and can even be lost in the off-gas[1]. Fine ores therefore undergo initial agglomeration through sintering or pelletization, before being charged to the blast furnace. During agglomeration through sintering, the raw material mixture first goes through a granulation process. In this process the iron ore fines, coke breeze, limestone and return sinter are mixed with water and tumbled in a rotary drum. Intermediate and fine particles (the adhering particles) then coat the coarser particles (the nucleus particles), through inter-particle adhesion via water bridges, whereby larger granules or quasi-particles form. These quasi-particles are larger in size and narrower in size range than the original feed[2,3].

A portion of these quasi-particles also reduce in size, due to breakage and attrition. The outer shell of the quasi-particle is therefore ‘active’ during granulation, as it is constantly breaking down and re-depositing[4,5].

Various authors define the sizes of the nucleus and adhering particles differently: according to Bergstrand *et al.*[6] the nucleus-forming particles are typically +1 mm, while the adhering particles are -0.5 mm in size, while Khosa and Manuel[7] reported the adhering size fraction to be -0.1 mm. Formoso *et al.*[8] defined the nucleus of the quasi-particle as being +0.7 mm, with the adhering fines as -0.2 mm.

The role of particles in the intermediate size range is still not completely understood: Lister and Waters showed that increasing

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proportions of adhering material decreases the granulation effectiveness, but decreasing the size of the adhering particles increases it[9]. Loo and Penny however, showed that replacement of an ore by one that contains a higher level of intermediate particles (+0.25–1.0 mm) can improve permeability[10].

Water addition, particle size distribution, ore porosity, surface properties of the iron ore and wettability of the iron ore by water are the most important factors that affect the granulation efficiency and permeability of the green sinter bed[10–14]. The permeability of the sinter bed in turn controls the productivity of the sinter plant, as well as the microstructure and properties of the produced sinter, as the gas flow rate through the bed governs the temperature profile through the bed. The process in which quasi-particles form is very strongly influenced by moisture that is available for granulation[13]. Sub-optimal moisture addition deteriorates green bed permeability rapidly[6]. The amount of moisture required for granulation varies widely with ore type[10,11,14]. Khosa and Manuel found that the optimum moisture could be described accurately by knowing the SiO_2, LOIT and Al_2O_3 (–1 mm) content of the ore, as well as the –0.15 mm and percentage of intermediate (+0.1 -1 mm) size fractions[7]. For most iron ores, an increase in particle size close to the 0.1 mm size range has the greatest effect on reducing permeability and increasing the amount of moisture that is required for granulation[7]. The use of different size fractions of coke breeze and flux in sinter mixes have been studied[15–17] as well as the use of coarse iron ore particles[10,18,19]. Bhagat *et al.*[15] reported that the micro-porosity of the sinter and its reducibility increased with a decrease in the size range of the coke breeze.

The reduction disintegration index (RDI) decreased, the reducibility decreased marginally and the productivity increased when the size range of the flux was narrowed down from –3 mm to -3 +0.5 mm. Hosotani *et al.* reported that the simultaneous removal of the –1 mm limestone fraction and the –0.5 mm coke breeze fraction improves the granulation index and permeability of the green sinter bed[16]. This led to a suppression in the shrinkage of the sinter cake, an increase in sintering rate (and therefore productivity), as well as improved reducibility due to an increase in the number of fine pores.

Kasai *et al.*[17] examined the influence of the use of unsized and sized coke fines and limestone on the pre-ignition permeability as well as the permeability of the bed during sintering. They found that the use of larger particles of coke and limestone resulted in improved permeability before and during sintering. The permeability of the produced sinter cake also depended largely on the pre-ignition permeability. This indicates that some aspect of the structure of a bed of granulated sinter feed is conserved during sintering.

Teo *et al.*[4] reported that large coke (+1.0 mm) and flux (limestone and serpentine) particles did not appear to pick up fine particles well. Fine coke particles can only be incorporated into the adhering fines layer when there is already an adhering layer present for them to imbed in. They hypothesized that coke is a poor granulating material, even in the nuclei size fraction (+1 mm), due to its hydrophobic surface properties[4].

Loo and Penny[10] reported that coarse, porous iron ore absorbed water and reduced the level of free water available for granulation, but improved the particle size distribution of the granulated mix. Two-stage coating granulation processes have also been investigated with the intent of improving productivity and reducibility of the sinter[4,20,21]. In these processes a certain target quasi-particle structure was achieved through divided flux additions, using two granulation drums. These processes did not always add benefits to the properties of the produced sinter.

Experimental

Raw materials

The raw materials used in the sintering experiments were Thabazimbi iron ore, Sishen iron ore, return fines, coke, lime, quartz, water and ferric chloride ($FeCl_3$). The following abbreviations are used to describe the examined samples:

- 20 and 80 (50 and 50) with fluxes: mixture of 20 mass per cent Thabazimbi iron ore, 80 mass per cent Sishen iron ore (50 mass per cent Thabazimbi iron ore, 50 mass per cent Sishen iron ore) with fluxes not sized
- (C and L): coke breeze and lime sized
- (C and L and R.F): coke breeze, lime and return fines sized.

The particle size distributions of the lime and coke breeze that were used are given in Table I. The return fines were sized by removing the –0.5 mm size fraction.

Granulation and permeability

The influence of moisture content and granulation time on the permeability and mean granule diameter was studied in the ranges of respectively 2–8 mass per cent and 2–10 minutes. A drum, with a diameter of 51.5 cm, height of 50 cm, at a constant rotational speed of 26 rotations per minute, was used. Ten samples of 10 kg (dry basis) of each raw material mixture were used. The procedure involved varying the moisture content of the mixture while keeping the time constant (5 samples), after which the effect of granulation time on permeability at optimum moisture content (5 samples) was examined. After granulation part of the granulated sample (approximately 4 kg) was used for a permeability test. A test apparatus, 0.595 m in height and 0.142 m in inside diameter, was used to measure the permeability, which was expressed in terms of the Japanese Permeability Unit (JPU) according to[11]:

$$JPU = V / A\left(H / \Delta P\right)^{0.6}$$

where: V: airflow rate (Nm^3/min)
A: area (m^2)
H: height of the bed (mm)
ΔP: suction applied across the bed (mmH_2O)

Table I

Particle size distributions of the coke breeze and lime (mass %)

	- 5 + 3.35 mm	- 3.35 + 1 mm	- 1 + 0.5 mm
Coke breeze	20	40	40
Lime	20	80	-

The permeability was calculated by taking the average of 3 measurements of pressure drop for different flow rates at the venturi, at the top and at the bottom of the test apparatus.

Sieve analysis

A portion of granulated sample was frozen with liquid nitrogen, in order to perform a sieve analysis on the granules, whereby the material transfer between granulometric classes (by comparing the size distribution before and after granulation) was studied. This was done by placing 500–700 g of granulated mixture on a metallic tray, after which liquid nitrogen (-200°C) was poured on the granulated sample and on the screen. The granulated sample was cooled together with the screen in order to avoid deterioration of the granules during sieving. The granule size distribution was determined by weighing the cooled fractions retained onto different screens after 5 minutes of screening. The results obtained are presented on semi logarithmic graphs, where the ordinate (arithmetic scale) shows the gain or loss as a percentage of the total sample weight, and the abscissa (logarithmic scale) shows the granulation class. Each point represents the difference between the quantities of material before and after granulation for each granulometric class. The following parameters were determined[22]:

X: The size limit between the reduced and increased granulometric fraction during the granulation process expressed in mm, considering that the reduced and increased granulometric fractions are the fractions whose relative percentages respectively reduce or increase after granulation. The value of **X** is obtained from the intersection of each curve with the x-axis of the semi logarithmic graph.

S: The level of material transfer between the reduced and increased granulometric fractions, expressed as a percentage of the total weight of the sample.

Ex: The efficiency of elimination of the fraction smaller than X mm, during the granulation process.

S and Ex are calculated from:

S = $(\%<X\ mm)_{BG}$ - $(\%<X\ mm)_{AG}$
= $(\%>X\ mm)_{AG}$ - $(\%>X\ mm)_{BG}$

Ex = 100*S/S' , where S' = $(\%<X\ mm)_{BG}$, and

$(\%<X\ mm)_{BG}$ = the weight fraction of grains less than X mm in the mixture before granulation, and

$(\%>X\ mm)_{BG}$ = the corresponding weight fraction above X mm.

$(\%<X\ mm)_{AG}$ = the weight fraction of grains less than X mm in the mixture after granulation, and

$(\%>X\ mm)_{AG}$ = the corresponding weight fraction above X mm.

Sintering

Sinter tests were carried out at Kumba Iron Ore pilot plant in a sinter pot with a cross-sectional grate area of 0.16 m^2. Four sinter mixtures, identified as the optimal mixtures after granulation, were investigated:

Mixture I: 50 and 50 (C and L and R.F), with 5.5 mass per cent moisture

Mixture II: 20 and 80 (C and L and R.F), with 4.5 mass per cent moisture

Mixture III: 20 and 80 (C and L), with 4.5 mass per cent moisture

Mixture IV: 50 and 50 (C and L), with 5.5 mass per cent moisture.

The compositions of these 4 mixtures are given in Tables II and III.

Table II

Composition of mixture I (mass %)

Raw material	Mixture I						
	1	2	3	4	5	6	7
Thabazimbi iron ore	24.94	25.62	25.20	24.88	24.13	24.56	24.17
Sishen iron ore	24.94	25.62	25.20	24.88	24.13	24.56	24.17
Return fines	26.00	24.00	25.00	26.00	28.00	27.00	28.00
Coke breeze	4.50	4.75	4.75	4.60	4.50	4.40	4.40
Lime	5.67	5.83	5.8	5.71	5.65	5.65	5.57
Dolomite	8.03	8.25	8.12	8.01	7.77	7.91	7.78
Silica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Ferric chloride	0.42	0.43	0.42	0.42	0.41	0.41	0.41
	100.00	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table III

Composition of mixtures II–IV (mass %)

Raw material	Mixture II	Mixture III		Mixture IV		
	8	9	10	11	12	13
Thabazimbi iron ore	9.80	9.79	9.74	9.85	9.78	9.94
Sishen iron ore	39.21	39.17	38.97	39.41	39.13	39.75
Return fines	28.00	28.00	27.00	28.00	27.00	26.00
Coke breeze	4.40	4.45	4.50	4.40	4.50	4.60
Lime	5.50	5.50	5.57	5.67	5.80	5.80
Dolomite	8.05	8.05	8.17	7.76	7.87	7.98
Silica	0.10	0.10	0.10	0.00	0.00	0.00
Water	4.50	4.50	5.50	4.50	5.50	5.50
Ferric chloride	0.44	0.44	0.44	0.41	0.42	0.43
	100.00	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Experimental results

Granulation and permeability

The permeability of both the 20 mass per cent Thabazimbi iron ore: 80 mass per cent Sishen iron ore mixture, and the 50 mass per cent Thabazimbi iron ore: 50 mass per cent Sishen iron ore mixtures increased as sized fluxes replaced the unsized fluxes, and reached a maximum when all the fluxes (coke breeze, lime and return fines) were sized (Figures 1 and 2).

When the moisture content in the granulated mixture was varied, while keeping the granulation time constant at 6 minutes, a maximum permeability of 49 JPU was achieved for the 20 mass per cent Thabazimbi iron ore: 80 mass per cent Sishen iron ore, sized coke breeze, lime and return fines mixture, at 4.5 mass per cent moisture.

When the influence of granulation time was examined at optimum moisture contents, the permeability of the 20 mass per cent Thabazimbi iron ore: 80 mass per cent Sishen iron ore, sized coke breeze, lime and return fines mixture was increased to 51 JPU when the granulation time was decreased to 4 minutes. The optimum moisture content and granulation time for the 50 mass per cent Thabazimbi iron ore: 50 mass per cent Sishen iron ore, sized coke breeze, lime and return fines mixture were respectively 5.5 mass per cent and 6 minutes (Figures 1 and 2).

The same trend was observed for the mean granule diameter (Figure 3): The biggest granules formed when the mixture 20 mass per cent Thabazimbi iron ore: 80 mass per cent Sishen, with sized coke breeze, lime and return fines were granulated. The average mean granule diameter of the mixture 20 mass per cent Thabazimbi iron ore: 80 mass per cent Sishen iron ore changed from 2.4 mm before granulation to 4.4 mm after granulation when only the coke and lime were sized, and from 3.0 mm to 4.8 mm when all the fluxes (coke, lime and return fines) were sized.

Variation in material transfer between granulometric classes

The variation in material transfer of the raw material mixture with fluxes between granulometric classes, for different moisture levels at 6 minutes of granulation are illustrated in Figures 4 to 9. In the mixture 50 mass per cent Thabazimbi iron ore: 50 mass per cent Sishen iron ore with fluxes not sized, fine particles have diameters smaller than 0.48 mm and coarse particles have diameters larger than 1.8 mm (Figure 4). When the coke and lime were sized, the diameters of the fine particles were smaller than 1 mm, and the coarse

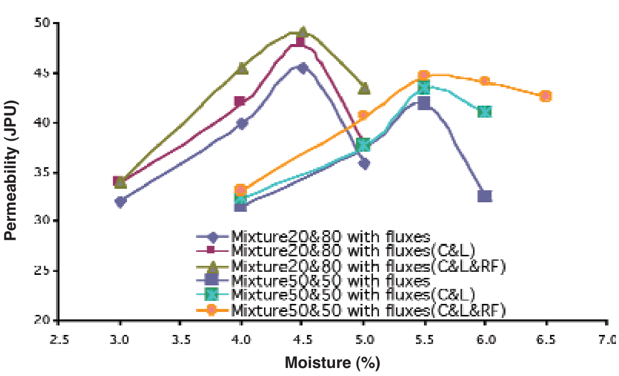

Figure 1—Influence of moisture content on permeability of the different iron ore mixtures with fluxes

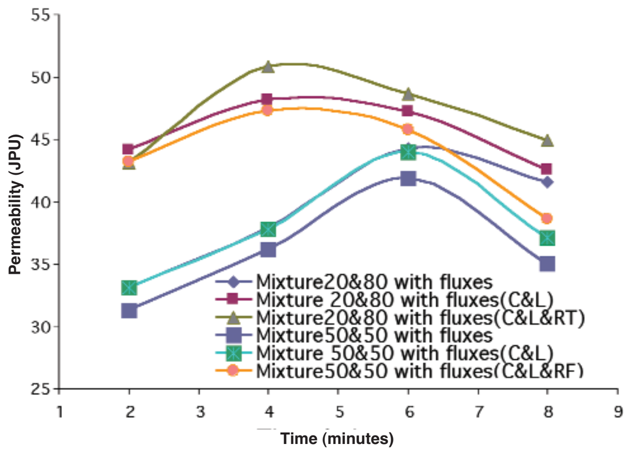

Figure 2—Influence of granulation time on permeability (moisture content for 20 and 80 mixtures is 4.5 mass per cent; moisture content for 50 and 50 mixtures is 5.5 mass per cent)

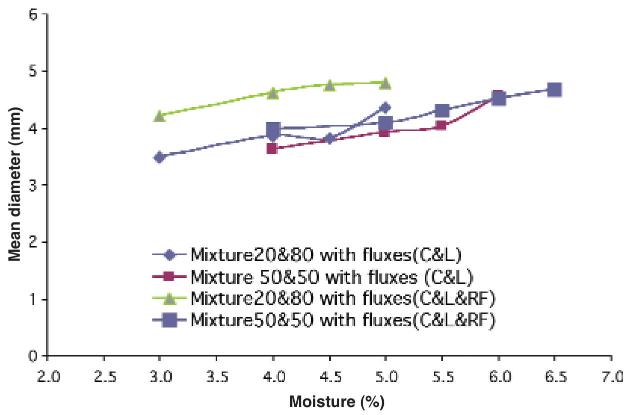

Figure 3—Influence of moisture content on the mean granule diameter of the different iron ore mixtures with fluxes (granulation time of 6 minutes)

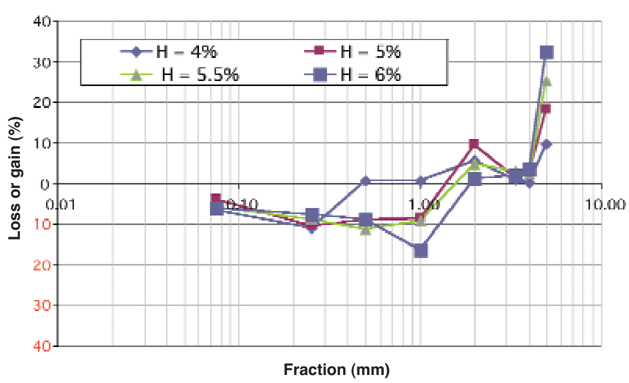

Figure 4—Variation in material transfer between granulometric classes for the mixture 50% Thabazimbi and 50% Sishen with fluxes not sized. (H = moisture content)

particles larger than 2.9 mm (Figure 5). However, when all the fluxes where sized, fine particles have diameters smaller than 2 mm and coarse particle have diameters larger than 3.35 mm (Figure 6). In the mixture 20 mass per cent Thabazimbi iron ore and 80 mass per cent Sishen iron ore with fluxes not sized, fine particles have diameters smaller than 0.9 mm and coarse particles have diameters larger than 2.9 mm (Figure 7). When the coke and lime were sized, fine particles have diameters smaller than 1.4 mm and coarse particle have diameters larger than 3.35 mm (Figure 8). When coke, lime and return fines were all sized, fine particles have diameters smaller than 2.4 mm and coarse particle have diameters larger than 3.35 mm (Figure 9).

Granulation potentials of mixtures of Thabazimbi and Sishen iron ores and fluxes

The results on the granulation potential of Thabazimbi and Sishen iron ores and their mixtures are summarized in Tables IV to IX. The granulation potential of a given iron ore mixture is better than another one if its permeability and the amount of material transfer (Ex) is higher at optimum moisture contents, and also if its moisture content (H) is less. The value of S indicates the amount of material transfer in mass percentage and the value of Ex shows which fines are eliminated effectively. D(B.G.) and D(A.G.) are respectively the mean diameter before granulation and after granulation, expressed in mm. In comparing the granulation potentials of mixtures containing 50 mass per cent Thabazimbi iron ore and 50 mass per cent Sishen iron ore, the mixture where the coke and lime were sized (Table V) present a better sinter mixture than the mixture where the coke, lime and return fines were sized (Table VI) and where the fluxes were not sized (Table IV). Although its permeability is slightly less than that of the mixture where the coke, lime and return fines were sized (44 vs. 45 JPU), it presents a higher

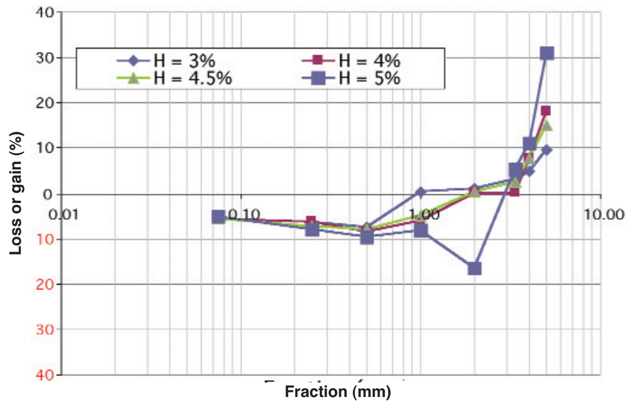

Figure 7—Variation in material transfer between granulometric classes for the mixture 20% Thabazimbi and 80% Sishen with fluxes, not sized. (H = moisture content)

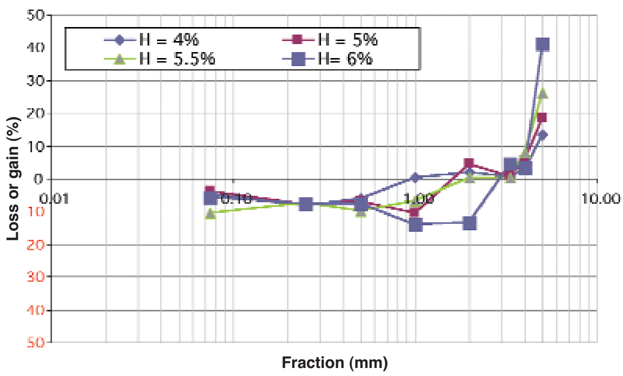

Figure 5—Variation in material transfer between granulometric classes for the mixture 50% Thabazimbi and 50% Sishen with only, coke and lime sized. (H = moisture content)

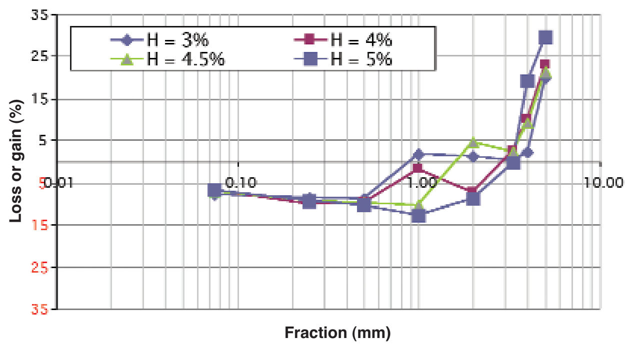

Figure 8—Variation in material transfer between granulometric classes for the mixture 20% Thabazimbi and 80% Sishen with coke and lime sized. (H = moisture content)

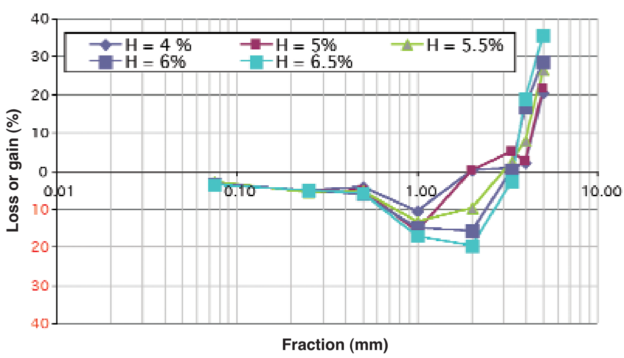

Figure 6—Variation in material transfer between granulometric classes for the mixture 50% Thabazimbi and 50% Sishen with coke, lime and return fines sized. (H = moisture content)

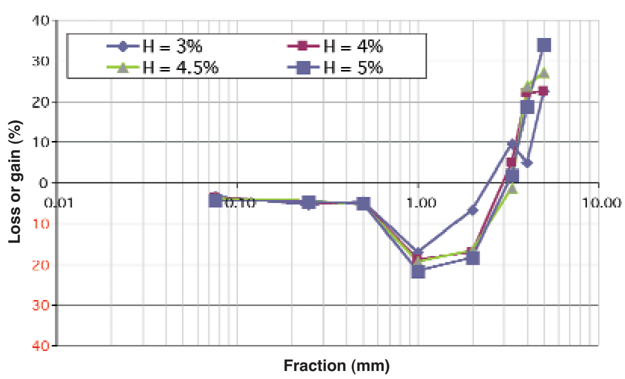

Figure 9—Variation in material transfer between granulometric classes for the mixture 20% Thabazimbi and 80% Sishen with fluxes, coke, lime, and return fines sized. (H = moisture content)

Table IV

Granulation potential of mixture 50 mass per cent Thabazimbi, 50 mass per cent Sishen with fluxes not sized

	H (%)	P (JPU)	X (mm)	S (%)	Ex (%)	D(B.G.) (mm)	D(A.G.) (mm)
Sample 1	4	32	0.48	17.5	98.7	2.51	3.15
Sample 2	5	38	1.50	31.9	61.5	2.45	3.61
Sample 3	5.5	42	1.60	35.1	73.3	2.59	4.01
Sample 4	6	33	1.80	39.3	85.6	2.65	4.34

Table V

Granulation potential of mixture: 50 mass per cent Thabazimbi, 50 mass per cent Sishen with coke and lime sized

	H (%)	P (JPU)	X (mm)	S (%)	Ex (%)	D(B.G.) (mm)	D(A.G.) (mm)
Sample 1	4	32	1.00	18.9	91.7	2.81	3.62
Sample 2	5	39	0.90	18.9	94.5	2.78	3.91
Sample 3	5.5	44	2.00	34.7	76.2	2.46	4.03
Sample 4	6	41	2.90	48.7	72.1	2.65	4.55

Table VI

Granulation potential of mixture: 50 mass per cent Thabazimbi, 50 mass per cent Sishen with coke, lime and return fines sized

	H (%)	P (JPU)	X (mm)	S (%)	Ex (%)	D(B.G.) (mm)	D(A.G.) (mm)
Sample 1	4	33	2.00	23.4	72.6	2.95	3.98
Sample 2	5	41	2.00	29.5	75.5	2.93	4.09
Sample 3	5.5	45	3.00	36.9	59.7	2.92	4.30
Sample 4	6	44	3.00	45.6	73.2	2.89	4.52
Sample 5	6.5	42	3.35	51.4	80.3	2.81	4.67

Table VII

Granulation potential of mixture 20 mass per cent Thabazimbi, 80 mass per cent Sishen with fluxes not sized

	H (%)	P (JPU)	X (mm)	S (%)	Ex (%)	D(B.G.) (mm)	D(A.G.) (mm)
Sample 1	3	32	0.90	19.3	96.2	2.53	3.34
Sample 2	4	40	1.80	26.4	64.1	2.55	3.73
Sample 3	4.5	46	2.00	25.7	63.4	2.64	3.73
Sample 4	5	36	3.00	47.4	66.4	2.53	4.62

Table VIII

Granulation potential of mixture: 20 mass per cent Thabazimbi, 80 mass per cent Sishen with fluxes, coke and lime sized

	H (%)	P (JPU)	X (mm)	S (%)	Ex (%)	D(B.G.) (mm)	D(A.G.) (mm)
Sample 1	3	34	1.40	25.39	89.1	2.34	3.49
Sample 2	4	42	1.70	37.04	76.5	2.35	3.85
Sample 3	4.5	48	3.00	35.97	48.7	2.32	3.81
Sample 4	5	38	3.35	48.61	67.4	2.41	4.36

efficiency of elimination of fine particles (Ex = 76.2% vs. 59.7%). The granulation potential of the mixture with 20 mass per cent Thabazimbi iron ore and 80 mass per cent Sishen iron ore with fluxes where the coke, lime, and return fines were sized (Table IX) was the highest with a permeability of 49 JPU, a high efficiency of elimination of fines (Ex = 86%), and a high level of transfer of fine particles to coarse particles (S = 50%).

Sintering

The quality of the produced sinters were evaluated and compared with the currently produced sinter (called the 'Base Case') in which the sinter mixture consists of 50 mass per cent Thabazimbi iron ore, 50 mass per cent Sishen iron ore and unsized fluxes, to which 5.25 mass per cent moisture is added during granulation (Table X). The sinter properties of

Table IX

Granulation potential of mixture: 20 mass per cent Thabazimbi, 80 mass per cent Sishen with fluxes, coke, lime and return fines sized

	H (%)	P (JPU)	X (mm)	S (%)	Ex (%)	D(B.G.) (mm)	D(A.G.) (mm)
Sample 1	3	34	2.40	31	77.1	2.92	4.20
Sample 2	4	46	3.00	49	85.0	3.05	4.61
Sample 3	4.5	49	3.35	50	86.0	3.06	4.75
Sample 4	5	44	3.20	54	89.3	2.92	4.79

Table X

Comparison of the sinter properties of Mixtures I–IV with those of the Base Case sinter

	Mixture I	Mixture II	Mixture III	Mixture IV	Base Case
Productivity.(t/24 h/m^2)	31.17	31.89	30.97	33.81	24.30
Coke rate. (kg/t.sinter)	80.60	79.38	80.44	80.82	93.26
Yield (%)	82.28	83.93	83.63	81.91	71.91
Sintering time (minutes)	21.15	20.98	21.63	20.10	25.70
TI (% + 6.3 mm)	71.00	71.15	71.42	71.34	73.75
TI (% -6.3 + 0.5 mm)	23.90	23.16	23.00	23.55	20.44
AI (% -0.5 mm)	5.10	5.69	5.58	5.11	5.81
RDI (% +6.30 mm)	29.15	19.70	25.00	30.30	21.88
RDI (% +3.15 mm)	64.50	57.95	60.75	66.70	62.31
RDI (% -0.50 mm)	5.25	5.90	5.70	5.00	5.53
RI (%/min)	1.45	1.52	1.25	1.15	1.60

Mixtures I–IV were found to be very similar, and superior to the Base Case sinter, with the exception of the TI (% + 6.3 mm) and the RDI(%-0.5 mm) in case of Mixtures II and III. The productivity and yield was improved when sized fluxes were added to the sinter mixture, while the coke rate, sintering time and AI(% -0.5 mm) were reduced. None of the sinters (including the Base Case sinter) conformed to the criteria of a RDI (% +3.15 mm) in excess of 70% and a RDI (% -0.5 mm) of less than 5%. All the examined sinters conformed to the requirements of TI (% + 6.3 mm) > 70 per cent and a RI ≥ 1 per cent per minute. Sinter Mixture IV had the shortest sintering time (20.1 min.), the highest productivity (33.8 t/24 h/m^2), a good RI (1.2%/min.), the highest RDI (% + 3.15 mm) (66.7%) and the lowest RDI (% - 0.5 mm) (5%), and is considered to be the best of the examined sinters. Mixture II has the highest yield (83.93%) and lowest coke rate (79.4 kg/t.sinter), and is considered to be the second best sinter mixture to Mixture IV.

Conclusions

- The permeability was the best at any granulation time for the mixture that contained 20 mass per cent Thabazimbi iron ore, 80 mass per cent Sishen iron ore and fluxes where the coke, lime and return fines were all sized
- When all the fluxes were sized, larger granules were formed compared to when only the coke breeze and lime were sized
- As water addition increased, the permeability increased and the granulation effectiveness improved, resulting in the formation of large particles. However, when water addition was increased beyond the optimum value, bed permeability and granulation deteriorated
- The growth in mean granule diameter during granulation is a function of the initial mean diameter before granulation, the amount of moisture, and the granulation time. As the time increased, the mean granule diameter increased up to a certain value and then started to decrease
- The removal of the -0.5 mm size fraction of coke breeze, -0.5 mm size fraction of return fines and -1 mm size fraction of limestone, as well as the use of higher proportions of Sishen iron ore, increased the size limit (X) between the reduced and increased granulometric fractions
- The mean granule diameter does not predict the permeability of the bed
- The mixture of 20 mass per cent Thabazimbi iron ore, 80 mass per cent Sishen iron ore with fluxes where the coke, lime and return fines were sized and the mixture 50 mass per cent Thabazimbi, 50 mass per cent Sishen with fluxes where only the coke and lime where sized have the best granulation potentials
- The sinter properties of the four sinters, in which the grain size distributions were controlled, are similar, but better than the base case sinter in which the fluxes were not sized. Sinter properties therefore benefit from grain size distribution control of the raw sinter mixture.

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